

## SAUROPODA (REPTILIA, SAURISCHIA) FROM THE CRETACEOUS OF QUEENSLAND

WALTER P. COOMBS, JR.

Pratt Museum  
Amherst College  
Amherst, Mass., 01002  
U.S.A.

and

R.E. MOLNAR  
Queensland Museum

### ABSTRACT

Five new specimens of Sauropoda have been collected from the Upper Cretaceous Winton Fm. in Queensland, Australia. Among the elements preserved are incomplete pectoral and pelvic girdles, fore- and hindlimb bones, metacarpals, and caudal vertebrae. Because of the fragmentary nature of the specimens, comparison to other sauropods is difficult, but the Winton sauropod appears to be a relatively primitive member of the suborder. There are few similarities to the Australian sauropod *Rhoetosaurus* and the specimens are tentatively identified as *Austrosaurus* sp.

### INTRODUCTION

In 1959, following the discovery of one bone by a station hand, Dr Alan Bartholomai collected several fragmentary dinosaur elements from Cretaceous sediments on Alni Station, northwest of Winton in Queensland. Four additional specimens are subsequently collected from the adjoining Elderslie and Lovelle Downs Stations by Dr Mary Wade of the Queensland Museum. All five specimens are referable to the Sauropoda, a group previously recorded from one Jurassic (Longman, 1926, 1927) and one Cretaceous specimen (Longman, 1933) in Australia. Sauropod elements, usually isolated, have also been found in the Lower Cretaceous near Hughenden (F6142, L349, and probably F2470), and at Chorregon, southeast of Winton (F10916), in Queensland, and probably at Lightning Ridge, New South Wales (F10230, a cast). Because of the general paucity of dinosaur remains in Australia, the five new specimens from Winton are deemed worthy of description despite their incomplete condition.

### ACKNOWLEDGMENTS

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### MATERIAL

Specimen F3390: Proximal and distal ends of humerus, proximal and distal ends of femur, proximal ends of three metacarpals; from Alni Station, about 1 km south of Alni homestead, 50 km northwest of Winton, Queensland (22° 11'S, 142° 28'E).

Specimen F6737: Nine caudal vertebrae, one partial neural arch, three partial dorsal vertebrae, partial scapula, proximal ends of ischium, rib pieces; from Lovelle Downs Station, about 3 km east-southeast of Lovelle Downs homestead, 50 km northwest of Winton, Queensland (22° 09'S, 142° 34'E).

Specimen F7291: One metacarpal, distal end of ?ulna, distal end of femur; from Lovelle Downs

Station, about 2 km east of Lovelle Downs homestead, 50 km northwest of Winton, Queensland (22° 09'S, 142° 33'E).

Specimen F7292: 18 caudal vertebrae, one ?carpal, two partial ulnae, two partial radii, two partial humeri, partial scapular blade, fragment of ?ilium, four metacarpals, rib pieces; from Elderslie Station, in triangle paddock near the woolshed, ½ km southwest of Top Horse Bore, about 4 km north-northeast of Elderslie homestead, 50 km northwest of Winton, Queensland (22° 15'S, 142° 29'E).

Specimen F7880: Coracoid (?), femoral head; from Elderslie Station, 2 km north of Top Horse Bore, about 6 km north-northeast of Elderslie homestead, 50 km northwest of Winton, Queensland (22° 13'S, 142° 29'E).

### STRATIGRAPHY

All specimens are from the Winton Fm. (of Whitehouse, 1954; see also Vine and Day, 1955) of middle Cretaceous, late Albian to early Cenomanian age (Dettmann, 1973). The bones were collected from the surface and probably represent a lag concentrate formed by deflation. The material probably comes from high within the Winton Fm. Associated fossils include silicified conifer wood, unionids, and lungfish. All specimen numbers refer to the Queensland Museum collections.

### DESCRIPTION

**DORSAL VERTEBRAE:** The anterior portions of the centra of three dorsal vertebrae are preserved in specimen F6737. Two of these are too poorly preserved to warrant description, while the other represents approximately the anterior third of the centrum. The anterior central face is distinctly convex, and the centrum itself depressed (about 20 cm wide by 15 cm deep). The anterior walls of small but deep pleurocoels are present. The extent of the pleurocoels is difficult to trace, but must have reached nearly the midline. As far as can be determined the pleurocoels were simple medially closed tubes with no sign of any expanded chambers as are often found among sauropods. The remainder of the centrum is filled with small chambers apparently entirely closed off from each other, as well as from the pleurocoels, by bony lamellae. This vertebra almost exactly matches an unfigured dorsal from the holotype of *Austrosaurus mckillopi* in the general form and proportions of the central face and anterior wall of the pleurocoel.

**CAUDAL VERTEBRAE (Plate 1):** Specimens F6737 and F7292 contain a total of 27 caudal centra plus a fragmentary neural arch. Three middle caudals in specimen F7292 are poorly preserved and provide few details worthy of note (Plate 1:D,E,K). Maximum transverse diameters of these centra exceed the length, and there is a slight but distinct dorsoventral compression. Neither these, nor any of the other caudal vertebrae have pleurocoels. The two largest centra in specimen F6737, possibly adjacent elements and derived from caudals five through twelve, are nearly circular in face view and are relatively short, maximum length being about half the maximum (Plate 1:A). The expanded, platycoelous articular ends are slightly offset such that the anterior end is higher than the posterior. The larger of these two centra retains the base of a massive, anteroposteriorly compressed diapophysis that arises from the juncture of the broken neural arch and the centrum. Chevron facets are not visible on either of these centra, and there are no diapophyseal struts and buttresses such as are found on anterior caudals of some sauropods. The next centrum of F6737, from near the middle of the tail, has less expanded articular ends than the preceding vertebrae, and its maximum diameter is only slightly greater than its length (Plate 1:B). A small, blunt diapophysis arises from the upper third of the centrum and slants obliquely backward and slightly upward. Bases of an anteriorly positioned neural arch occupy about half the length of this centrum (Plate 1:B2). Broad, blunt chevron facets face downwards and backwards at the posterior margin of the centrum. Length and transverse diameter are subequal on the next more posterior vertebrae of F6737 (Plate 1:C), which was separated from the centrum previously described by two or three missing elements. Broken bases of the diapophyses arise about one-third of the centrum's height below the neural arch and near midlength. Neural arch bases are positioned toward the anterior end of the centrum, and chevron facets are not preserved.

The next four vertebrae of specimen F6737 are from the distal half of the tail (Plate 1:G,H,I,J). All are platycoelous to amphiplatyan but with centrally placed concavities in the faces, and are nearly circular in end view. All four of these centra are about the same length, but maximum diameter decreases regularly through the series. In section the bottom of each centrum is formed by a broad, flat surface. Neural arch bases are uniformly set toward the anterior end of the

centra, and diapophyses are absent. Blunt chevron facets protrude from the posterior margin of each centrum, but there is only a faint suggestion of corresponding facets anteriorly (Plate I:I).

A series of twelve small caudals in specimen F7292 comes from the distal third of the tail (Plate I:L through Y). The most anterior of the set comes from about the same point along the tail as the smallest caudal in specimen F6737. All twelve distal caudals have lengths greater than their maximum transverse diameter. Expanded articular ends are platycoelous to amphiplatyan on the more anterior caudals of this series, becoming biconvex on the distal centra (although always retaining a central concavity). Chevron facets, barely projecting off the central articular surface are visible on several centra of this series, and diapophyses are absent from all, as would be expected in distal caudals. Neural arches sit toward the anterior end of each centrum, being centred about one-third of the way back, shifting further back on the more distal vertebrae. Two nearly complete neural arches on vertebrae near the middle of this series are low (neural spines not developed) and simple in structure (Plate I:Q,S). In section the bottoms of the centra show a broad, flat surface.

A fragmentary neural arch in specimen F6737 is probably derived from an anterior caudal but cannot be fitted to any of the centra described above (Plate I:F). A single prezygapophysis on this fragment is a simple massive projection devoid of supporting struts and laminae and its anteroposteriorly elongate articular surface is flat. The neural arch wall is entirely filled with spongy bone with no sign of a pleurocoel.

**SCAPULA** (Plate II:D,E, Plate III:A,B): A fragmentary scapular body in specimen F6737 preserves much of the glenoid and the coracoid articulation (Plate II:D,E). The thickened glenoid region has a concave articular surface whose transverse and longitudinal dimensions are about equal. A narrower but longer coracoid articulation meets the glenoid at an angle of 115°. The 'spine' of the scapular body runs forward perpendicularly to the posterior margin, at an angle of about 40° to the coracoid articular surface. The posterior margin at about this point is produced back into a shallow 'shelf', which in section forms an acute angle unlike the rounded section of the posterior margin closer to the glenoid. This 'shelf' is the presumptive attachment of the serratus ventralis or biceps brachii. In general form, so far as can be determined from such an incomplete specimen, the body of the scapula resembles most closely

that of *Laplatasaurus araukanicus* (von Huene, 1929).

A flattened fragment in specimen F7292 is a broken scapular blade (Plate III:A,B). The piece is 60 cm long by 24 cm wide with a slightly concave medial surface and a low, longitudinal ridge along the outer surface. This elongate ridge is offset towards what is regarded as the anterior edge of the blade.

**CORACOID** (Plate II:A,B,C): Specimen F7880 includes an approximately equidimensional element identified as a coracoid. The element shows an open coracoid notch rather than a closed foramen (Plate II:A). Although there is considerable breakage around the notch, at one point unbroken bone surface can be traced from within the notch onto the outside, scapular articular surface. A massive and rather long, narrow, convex scapular articulation and a short, broad, concave glenoid region are present. Specimen F7292 contains a possible second coracoid (Plate II:B,C). The fragment is shallowly concave on one surface, convex on the opposite. A massive thick region protruding from one edge probably represents the base of the glenoid. The actual articular surface of the glenoid as well as all of the scapular contact region is missing.

**HUMERUS** (Plate III:C,D,E,I,J): A very fine proximal end of a humerus together with a detached distal end, probably of the same bone, are included in specimen F3390. The proximal end is strongly compressed anteroposteriorly forming a wide, gently convex extensor surface and a broad, shallowly concave flexor surface (Plate III:I). A well delineated, roughly oval head lies near mid-width of the proximal end and extends back onto the extensor surface (Plate III:J). The head is better defined, has a smoother articular surface, and extends somewhat farther onto the extensor surface than is typical among sauropods. Subequal medial and lateral processes slope away from the head, both processes ending in fairly sharp shoulders where they meet the shaft. Most adult sauropod humeri have a more rounded, less angular proximal end. Only the most proximal end of the delto-pectoral crest is preserved as indicated by the thickened lateral margin of the shaft.

The broken distal end of a humerus in specimen F3390 may be part of the same bone as the preceding piece (Plate III:D,E). At least half the ulnar condyle as well as the median posterior region of the radial condyle are missing. As with the humeral head, the distal articulations are more clearly defined on this specimen and have smoother articular surfaces than is typical of

sauropods. Viewed laterally the ulnar condyle has an almost circular curve with little flattening at the distal end. Both ulnar and radial condyles wrap well up onto the flexor surface. As preserved, the distal humeral fragment is about 38 cm long, the proximal fragment about 21 cm long. Assuming the humerus was massive and short as in *Apatosaurus* would give an estimated original length of about 80 cm. Assuming a long slender humerus as in *Brachiosaurus* would give an original length of up to 120 cm. The Queensland material is fairly similar to *Cetiosaurus* (see discussion below), and restoring the humerus after this genus gives an estimated original length of about 90 cm, short for a sauropod.

A rather battered humerus in specimen F7292 includes most of the shaft but is missing both articular ends (Plate III:C). Proximally this specimen is broad, with a wide, shallow flexor surface bounded by a thin delto-pectoral crest. Distally the bone narrows and thickens to an oval cross section. In most sauropods the humerus remains wider and more anteroposteriorly compressed toward the distal end. The degree of tapering in the Queensland specimen is somewhat unusual, but is matched by the humerus of *Dinodocus mackesoni* (Woodward, 1908). As preserved the humerus of specimen F7292 is about 90 cm long with a maximum width of 38 cm. The original length of the humerus is estimated at 110 to 120 cm, a moderate size for a sauropod.

A badly shattered proximal end of a humerus in specimen F7212 adds little additional information. As in specimen F3390, the medial process meets the shaft at a fairly sharp angle, but the head in specimen F7292 is not as well defined because of post mortem damage. Distally the shaft of this fragment appears to be more compressed than that of F7292, but again this may be a matter of poor preservation.

**ULNA** (Plate IV:A,B,C): Specimen F7292 includes shafts of two ulnae, one of which retains the distal articular surface intact and the proximal end as a detached fragment. Proximally there is a broad, flat anterior surface and a posterior ridge that rises to a low, rugose olecranal process, so that sections through the proximal end are irregularly triangular with the widest surface facing the radius and the most obtuse corner formed by the olecranal process (Plate IV:A,B). Sections through the distal region of the ulna are crudely circular. The distal articular surface is rugose and irregularly shaped, but is roughly circular when viewed end-on. The alae that embrace the radius are greatly prolonged distally,

extending down about 80 per cent of the length of the ulna. In other sauropods the alae rarely extend more than 60 per cent of the ulnar length. As preserved, the longer shaft piece is 67 cm long exclusive of the isolated proximal end (which is 24 cm long). The original length of the ulna is estimated at about 95 cm.

**RADIUS** (Plate IV:D,E): There are two almost complete radii in specimen F7292. Most of the radial shaft is roughly circular in section, with a somewhat flattened surface facing the ulna. Distally the radius is anteroposteriorly compressed, with the distal articular surface at an angle of about 70° to the long axis of the shaft. The radius is more massive than usual among sauropods, with a more marked distal expansion. The proportions are matched by those of several titanosaurid radii. The proximal end seems also compressed, but much of it has been lost from both radii. The more complete radius, which retains fragments of the proximal articular surface, measures 80 cm in length (Plate IV:D).

**ISCHIUM** (Plate III:F,G,H): The proximal end of a right ischium in specimen F6737 preserves both articular surfaces and part of the acetabulum, but is lacking all of the blade (Plate III:F,G,H). The massive iliac articulation is slightly convex and in face view forms a half-moon shaped surface whose flat margin is directed laterally. A more elongate, less massive pubic articulation is shorter and straighter than in most Sauropoda. The pubic and iliac articular surfaces are set at an angle of about 65° to each other, a rather low value for sauropods. Along the margin of the acetabulum the ischium thins down to an almost blade-like edge, much of which has been broken off.

**FEMUR** (Plate V:A,B,E through J): Specimen F3390 includes proximal and distal ends of a femur that is missing the intervening shaft, the two femoral pieces being among the best of the Winton material (Plate V:A,B,G,H). The femoral head is elevated well above the level of the greater trochanter and is displaced medially so as to project well into the acetabulum. As is typical of sauropods, the head blends into the laterally positioned trochanters with no intervening groove or furrow. In anterior view the femoral head looks bulbous and rounded, but a proximal view reveals strong anteroposterior compression that echoes a similar compression of the shaft, at least some of which is due to post-mortem crushing (Plate V:A). There is a slight hip or bulge along the lateral edge of the shaft a little distal to the greater



trochanter, and a similar bulge along the medial edge further distal. These two hips give the proximal third of the femur a weakly sinuous curvature in anterior view (Plate V:B). The bulge along the medial edge of the femur is associated with a low, ridge-like fourth trochanter. The femoral shaft is anteroposteriorly compressed, but is not very broad, and consequently gives the impression of being a long, slender element.

A second isolated femoral head in specimen F7880, twice as large as that of F3390, is less compressed and more nearly spherical in proximal view. It somewhat resembles the femoral head of *Amphicoelias* (Osborn and Mook, 1921, fig. 125).

Articular surfaces of the distal femoral piece in specimen F3390 wrap well up onto both anterior and posterior surfaces of the distal femoral shaft. Viewed laterally these condyles form almost a semicircle with a slight flattening of the distalmost surface. A deep furrow separates a longer medial condyle from a broader lateral condyle slightly inset posteriorly from the lateral margin of the shaft. As in many other sauropods the medial condyle shifts toward the center of the femoral shaft as it curves up the flexor surface. As preserved, the combined femoral head and proximal shaft piece of specimen F3390 are about 56 cm long; the distal femoral piece is about 31 cm long giving a minimum femoral length of over 85 cm. Assuming that the femur of the Winton sauropod was proportioned similarly to that of *Cetiosaurus* would imply a missing shaft segment amounting to approximately one-third the total femoral length, giving an estimated original length of about 127 cm, a moderate size for a sauropod. The distal femoral piece of specimen F7291 is very similar in form to that of specimen F3390 and about 20 per cent larger (Plate V:I,J).

**MESOPODIAL** (Plate VI:R,S): A flat, block-like bone in specimen F7292 is tentatively identified as a carpal. In face view the element is roughly circular with one flattened margin (Plate VI:S). Maximum diameter is a little less than twice the thickness of this element. In size and general conformation this bone resembles a 'probable carpal' of *Camarasaurus grandis* (Ostrom and McIntosh, 1966, pl. 79, figs. 1-5).

**METAPODIALS** (Plate VI:A through Q): Specimen F3390 contains proximal ends of three metacarpals I, II(?), and III (Plate VI:L through Q). Metacarpal I is by a slight margin the largest of the three. Its articular end is bounded anteromedially by a long convex border, anteriorly by a short straight edge, posteriorly by a longer

straight segment, and laterally by a shallow concave surface which receives mc II. The element doubtfully identified as mc II is the smallest metacarpal of F3390. Its articular surface is bounded by a short, convex anterior (?) margin and longer medial and lateral edges. There is a blunt projection anterolaterally that presumably contacted mc III. With its characteristic triangular shape in proximal view (Plate VI:P), mc III is the most readily identified of these three bones. The anterior border of its articular surface is shorter than the subequal medial and lateral edges. In anterior or medial view all metacarpals show gently convex articular ends.

Specimen F7292 includes four metacarpals. Mc I is represented by the proximal end which has the characteristic flat, oval articular surface with a flattened, downturned border facing mc II (Plate VI:J,K). Two fragments tentatively identified as mc II are missing the middle region of the shaft (Plate VI:F,G,H). The damaged proximal articulation is irregularly triangular in outline. An almost complete mc III has a slightly damaged proximal end that still retains the typical triangular shape (Plate VI:I). This element is about 42 cm in length, very large even for a sauropod. The final metacarpal of specimen F7291 is missing some of the proximal end, but the damaged upper shaft is roughly triangular suggesting that this element is another mc III (Plate VI:A,B,C). As preserved, this bone is about 41 cm in length.

Specimen F7291 contains a single, almost complete metacarpal I that measures about 37 cm in length (Plate VI:D,E). The proximal articular face has a shape almost identical to that of mc I of specimen F7292.

In proximal view the metacarpals of specimen F3390 are quite different in form from those of specimens F7291 and F7292. There is little likelihood that any of these specimens are misidentified metatarsals, so that either there are two sauropods represented, or the metacarpal form altered with growth (metacarpals of specimen F3390 are about one-half the size of those of specimen F7292). Some of the sauropod material from near Hughenden is quite distinct from that from Winton, and suggests that there were at least two different sauropods during the Cretaceous in Queensland.

**OTHER FRAGMENTS** (Plate VI): Several bones among the specimens described here are difficult to identify positively because of their fragmentary, shattered condition. Several of these elements are in specimen F7291, including the distal articular

surface of a long bone that is roughly circular in end view and is tentatively identified as the distal end of an ulna. A badly crushed end of a large bone (Plate V:C,D) included in this specimen may be the proximal end of an ulna, but is too incomplete for confident identification. Another massive fragment in specimen F7292 may well be part of the anterior portion of an ilium, but again the specimen is too fragmentary for certain identification (Plate II:F,G).

Both specimens F7292 and F6737 include fragments of ribs. Those of specimen F7292 measure in section about 5 by 8 cm, while those of specimen F6737 are distinctly thinner, measuring 2 by 5 cm.

### DISCUSSION

Although the Winton specimens described herein are clearly sauropod, their fragmentary condition is a severe barrier to determining more intimate relationships to other genera. Moreover, it is generally agreed that no satisfactory system of sauropod taxonomy has yet been devised, and that sauropod nomenclature at the generic and specific level is in great need of extensive review and revision (e.g. Ostrom, 1970). Family group names follow Romer (1956) as a descriptive convenience, not because Romer's taxonomic system is preferable. It is not clear how many taxa are represented by the five specimens from Queensland. There is certainly a considerable size difference between the relatively small individual represented by specimen F3390, and the considerably larger animal of specimen F7292. Moreover there are the differences in metacarpal and rib form previously described: these differences however are insufficient to confidently indicate the presence of more than one taxon. Thus for this discussion all of the Winton material is grouped together and is considered a single species. The groups considered here are ranked in increasing similarity to the Winton sauropod, except that the two previously described Australian sauropods (*Rhoetosaurus* and *Austrosaurus*) are discussed last.

**DIPLODOCINAE AND APATOSAURINAE:** *Diplodocus* is one of the best known sauropods (Osborn, 1899; Hatcher, 1901; Holland, 1906; Gilmore, 1932), but other Diplodocinae, particularly *Barosaurus* and *Amphicoelias*, are only poorly known (Lull, 1919; Janensch, 1929, 1935, 1961; Osborn and Mook, 1921). *Apatosaurus* (= *Brontosaurus*) is another thoroughly studied genus that is close morphologically to *Diplodocus* (Hatcher, 1902; Riggs, 1903; Osborn, 1905;

Holland, 1915; Gilmore, 1936; Berman and McIntosh, 1978), and in fact probably does not warrant separation into its own subfamily. These genera are among the most advanced of the sauropods. They differ from the Winton sauropod in having the following features: 1) pleurocoels in anterior caudals; 2) tall and generally complex caudal transverse processes and caudal ribs; 3) more strongly expanded articular faces on caudal centra; 4) neural arches at approximately mid-length of caudal centra; 5) moderately procoelous anterior caudals (but not as strongly procoelous as in the Titanosaurinae); and, 6) large pleurocoels in the dorsals. Additionally, *Barosaurus*, *Diplodocus* and *Apatosaurus* have massive femora with poorly defined heads at most slightly elevated above the level of the proximal trochanters, not at all like the elevated head of the femur in specimen F3390. In *Amphicoelias* the femoral head is well above the level of the trochanters, the head is subspherical and the femoral shaft nearly circular in section, a possibly unique configuration among sauropods (Osborn and Mook, 1921). Specimen F7880 also has an isolated femoral head of subspherical shape. *Amphicoelias* however differs from the Winton sauropod in having amphicoelous dorsals with small pleurocoels, more gracile ulnae with shorter radial alae, and in lacking the 'shelf' along the posterior margin of the scapula. In spite of a few similarities, the Winton sauropod cannot be considered a member of the Diplodocinae or Apatosaurinae.

The Chinese *Mamenchisaurus* (Young, 1954, 1958, Young and Chao, 1972) is considered here in view of the similarity of its chevrons to those of *Diplodocus* (Berman and McIntosh, 1978). It shows no close resemblance to the Queensland material and differs in the following points: 1) less marked development of the humeral head; 2) radius with less constriction at midshaft, and less dilation of the distal end; 3) femur with less marked elevation of the head above the level of the proximal trochanters (although bulges of the lateral and medial margins are present as in the Winton sauropod); and, 4) proximal caudals markedly procoelous. Thus *Mamenchisaurus* shows no special similarity to the Winton sauropod material.

**TITANOSAURINAE:** As used by Romer (1956) this large subfamily includes most Cretaceous sauropods as well as many sauropod taxa from Gondwanaland, including *Titanosaurus*, *Antarctosaurus* and *Laplatasaurus* (Lydekker, 1893; Huene, 1927, 1929, 1932; von Huene and Matley,

1933). Although some species are similar to the Winton sauropod in scapular form, especially the posterior marginal 'shelf', and in having a robust radius, titanosaurs differ in having strongly procoelous anterior caudals. Amphiplatyan centra are present by the middle third of the tail in many titanosaurs, but because the anterior caudals of the Winton sauropod are clearly not procoelous, the subfamily Titanosaurinae is dismissed from further consideration. This decision is contingent on having correctly estimated the position in the caudal series of the isolated caudal centra of specimen F6737 in particular, but their size relative to the other caudals and the dorsal pieces lends confidence to this determination. Other differences include a usually less well-marked humeral head (although *Antarctosaurus brasiliensis* Arid and Vizotto, 1971, has a proximal humerus of very similar form), shorter radial alae of the ulnae, and femoral head less clearly elevated above the trochanters.

**EUHELOPODINAE:** Two genera considered to belong to this group by Romer (1956). *Euhelopus* (Wiman, 1929) and *Tiانشanosaurus* (Young, 1937), have a 'shelf' along the posteroventral scapular margin similar to that in the Winton sauropod. This is, however, the only obvious similarity. Both genera differ from the Queensland material in having an angle of 90° or more between the ilial and pubic articular surfaces of the ischium, and in lacking the marked elevation of the femoral head above the level of the proximal trochanters. In addition the humerus of *Euhelopus* (Young, 1935) shows less development of the head than in the Winton sauropod.

**CAMARASAURINAE:** As defined by Romer (1956), this subfamily contains only *Camarasaurus*, a genus represented by one of the most complete sauropod skeletons ever found (Gilmore, 1952; Riggs, 1901; Osborn, 1906; Gregory, 1919; Osborn and Mook, 1921; Lull, 1930). Borsuk-Bialynicka (1977) considered *Opisthocoelicaudia* to be a second genus referable to the Camarasaurinae. *Camarasaurus* anterior caudals are amphicoelous or platycoelous, and the general contour of centra from comparable regions of the tail is similar to the Queensland specimens. *Camarasaurus* also has simple transverse processes on caudals, and bifid chevron facets that are more prominent at the posterior than the anterior end of caudal centra. The arches of the seventh through fifteenth caudals of *Camarasaurus* are shifted anteriorly as in the Winton sauropod. *Camarasaurus* has only a slight lateral bulge of the femoral shaft just distal to the

greater trochanter. The medial edge of most *Camarasaurus* femora are smoothly convex, no bulge in the region of the fourth trochanter as found in the Winton specimens. Other differences in *Camarasaurus* femora include a head that is only slightly elevated above the level of the trochanters, and a shaft that is very broad distally. These differences could result from the larger size of *Camarasaurus* relative to specimen F3390. The humerus of specimen F3390 has a better defined head that extends farther onto the extensor surface than the head of a *Camarasaurus* humerus. An angle of about 110° between the iliac and pubic articulations of a *Camarasaurus* ischium, compared with about 65° in the Winton sauropod, is a more convincing point of distinction, and the dorsals of *Camarasaurus* show cavernous pleurocoels quite unlike those of the fragmentary dorsals of the Winton sauropod.

*Opisthocoelicaudia* differs from the Winton sauropod in having: 1) extensive pleurocoels in the posterior dorsals; 2) anterior caudals (to the fifteenth) that are markedly opisthocoelous; 3) a more robust humerus, with less prominent head; 4) more robust radius, ulna and metacarpus; and 5) a femur generally similar to that of *Camarasaurus*. The posterior dorsals are similar to those of the Winton sauropod in being strongly opisthocoelous with depressed centra. Such isolated points of similarity do not suggest any close relationship of the Winton sauropod with the camarasaurines.

**BRACHIOSAURINAE AND CETIOSAURINAE:** Differences between these two subfamilies include: 1) deep pleurocoels in anterior dorsals of Brachiosaurinae, solid centra in Cetiosaurinae; 2) very long neck in Brachiosaurinae, moderate in Cetiosaurinae; and 3) forelimb as long or longer than hindlimb in Brachiosaurinae, hindlimb longer than forelimb in Cetiosaurinae. In most skeletal elements and morphologic features where comparisons can be made to the Winton sauropod, the subfamilies Cetiosaurinae and Brachiosaurinae are essentially identical. The only well known genus of the Brachiosaurinae is *Brachiosaurus* itself (Riggs, 1904; Janensch, 1936, 1950). *Pleurocoelus* and *Bothriospondylus* are represented by relatively poor material while *Pelorosaurus* is known almost entirely from isolated elements. The very long metacarpals of the Winton sauropod are suggestive of the Brachiosaurinae, but the two fragmentary humeri among the Queensland material are rather short for a *Brachiosaurus*-like genus, and the angular proximal end of the humerus in specimen F3390



is quite unlike the rounded adult proximal humerus of *Brachiosaurus*. Femora of *Brachiosaurus* have a marked lateral bulge just distad to the greater trochanter, but the posterior dorsals of *Brachiosaurus* (and other brachiosaurs) show more extensive pleurocoels than those of the Winton sauropod suggesting that it is unlikely to be a brachiosaurine.

No genus of the Cetiosaurinae is represented by a really good specimen, but some comparisons are possible with *Cetiosaurus* itself as well as with *Haplocanthosaurus*. *Cetiosaurus* femora are similar to those of the Winton sauropod in degree of elevation of the head above the level of the greater trochanter and in having both a lateral bulge of the shaft just distal to the greater trochanter, and a medial bulge in the region of the fourth trochanter (Phillips, 1871; de Lapparent, 1955). A *Cetiosaurus* coracoid figured by Lapparent (1955, Pl. IV) is close in form to that of the Winton sauropod. *Cetiosaurus* is also similar in having neural arches set towards the anterior margin of caudal centra and in having prominent, bifid chevron facets only at the posterior end of caudal centra (Phillips, 1871, Fig. 45). An angle of about 80° between the pubic and ilial articulations of a *Cetiosaurus* ischium (Reynolds, 1939) is close to the 65° of that of the Winton specimen.

In *Haplocanthosaurus* (Riggs, 1904; Hatcher, 1903) the femoral head is more elevated above the level of the proximal trochanters than in the Winton specimens. *Haplocanthosaurus* also differs in the following features: 1) medial edge of the femur without a bulge in the region of the fourth trochanter; 2) neural arches at midlength of caudal centra; 3) angle between ilial and public articulations of ischium about 95°; and 4) dorsals with more extensive pleurocoel development.

All genera included in the subfamilies Cetiosaurinae and Brachiosaurinae are similar to the Winton sauropod in the following respects: 1) no pleurocoels in caudal centra; 2) caudals platycoelous to amphiplatyan; 3) chevron facets not confluent; 4) chevron facets larger at posterior end of centrum than at anterior end; 5) femoral head elevated above level of proximal trochanters; 6) lateral bulge of shaft just distal to the greater trochanter of femur; and 7) angle between ilial and pubic articulations of ischium less than in 'advanced' sauropods (e.g. *Apatosaurus*, *Diplodocus*, and *Camarasaurus*), but brachiosaurs differ in dorsal pleurocoel form: both brachiosaurs and cetiosaurs lack the robust radius of the Winton sauropod. Among the sauropod groups

recognised by Romer (1956), the Cetiosaurinae includes genera that are most similar to the Queensland material described herein.

**RHOETOSAURUS:** *Rhoetosaurus brownei*, known from a single specimen from the Jurassic of Queensland (Longman, 1926, 1927) has been classified as a cetiosaurine (Romer, 1956), and is similar to the Winton sauropod in most of the features noted in the preceding section. Linear dimensions of the *Rhoetosaurus* specimen are 40–50% larger than elements of specimen F3390, but are only slightly larger than the individual represented by specimen F7292. The massive femur of *Rhoetosaurus* has a poorly defined head only slightly elevated above the greater trochanter, and there is no outward bulge of the femoral shaft just below the trochanter. The dorsals of *Rhoetosaurus* have large pleurocoels, but there are no caudal pleurocoels. The anterior chevron facets are probably confluent, and the chevrons wedge equally between posterior and anterior faces of adjacent caudal centra. There are no signs of struts or buttresses associated with the diapophyses of the caudals, and the neural arch is centrally placed on the centra. The caudals are generally similar in form to those of the Winton sauropod, but the dorsals are clearly different. Because of the incomplete condition of the *Rhoetosaurus* type and the new Queensland specimens, no other comparisons are possible.

**AUSTROSAURUS:** *Austrosaurus mckillopi* from the Lower Cretaceous (Allaru mudstone, Albian) of north central Queensland is known only from the type specimen, a series of six fragmentary dorsal vertebrae (Longman, 1933). These vertebrae are deeply opisthocelous with relatively small pleurocoels and an extensive, cancellous internal structure that is distinctive (Longman, 1933), and matched in the Winton sauropod dorsal pieces. *Austrosaurus* is not readily placed in a group with the other sauropod genera, and consequently it has been classified in the Cetiosauridae (Longman, 1933), the Brachiosauridae (Romer, 1966), and as Sauropoda, *incertae sedis* (Romer, 1956), the last assignment being the most realistic if not the most satisfactory. Dorsal vertebral pieces of the Winton sauropod (specimen F6737) match in form and internal structure those of *A. mckillopi*, although there is a possibility that the centra of the Winton sauropod were less strongly constricted than those of *Austrosaurus*. Thus tentative reference of the Winton sauropod material to *Austrosaurus* sp. is warranted.



## SUMMARY AND CONCLUSIONS

Cretaceous sauropod remains from Queensland, Australia, described herein, have the following significant features: 1) no struts and buttresses supporting diapophyses of caudal vertebrae; 2) no pleurocoels within caudal centra; 3) neural arches set toward anterior end of caudal centra; 4) likely 'open' chevrons articulating intervertebrally; 5) chevron facets at posterior end of centra larger than at anterior end; 6) angle of about 65° between pubic and iliac articular surfaces of ischium; 7) a notch rather than a foramen in the coracoid; 8) joint surfaces of long bones smoother and better defined than is typical of sauropods; 9) humerus tapers greatly distal to delto-pectoral crest, shaft section not greatly compressed; 10) femoral head elevated above level of proximal trochanters; 11) metacarpals exceptionally large, both relative to other limb elements and absolutely, compared to other sauropods; 12) exceptionally long radial alae of ulnae; 13) small dorsal pleurocoels; 14) cancellous internal structure in dorsal centra, similar to that found in *Austrosaurus mckillopi*; and 15) a well-developed 'shelf', along the posteroventral margin of the scapula. The new material has few similarities to the Australian Jurassic sauropod *Rhoetosaurus*, but (partially perhaps for want of homologous elements) cannot be distinguished from the Australian Cretaceous sauropod, *Austrosaurus*. Distinct similarities to *Austrosaurus* are found in the structure of the dorsals. We regard the present material as inadequate for proper definition of a new taxon, and the specimens are here classified as *Austrosaurus* sp. and considered most likely to belong to the Cetiosaurinae (*sensu* Romer, 1956) among currently defined sauropod groups.

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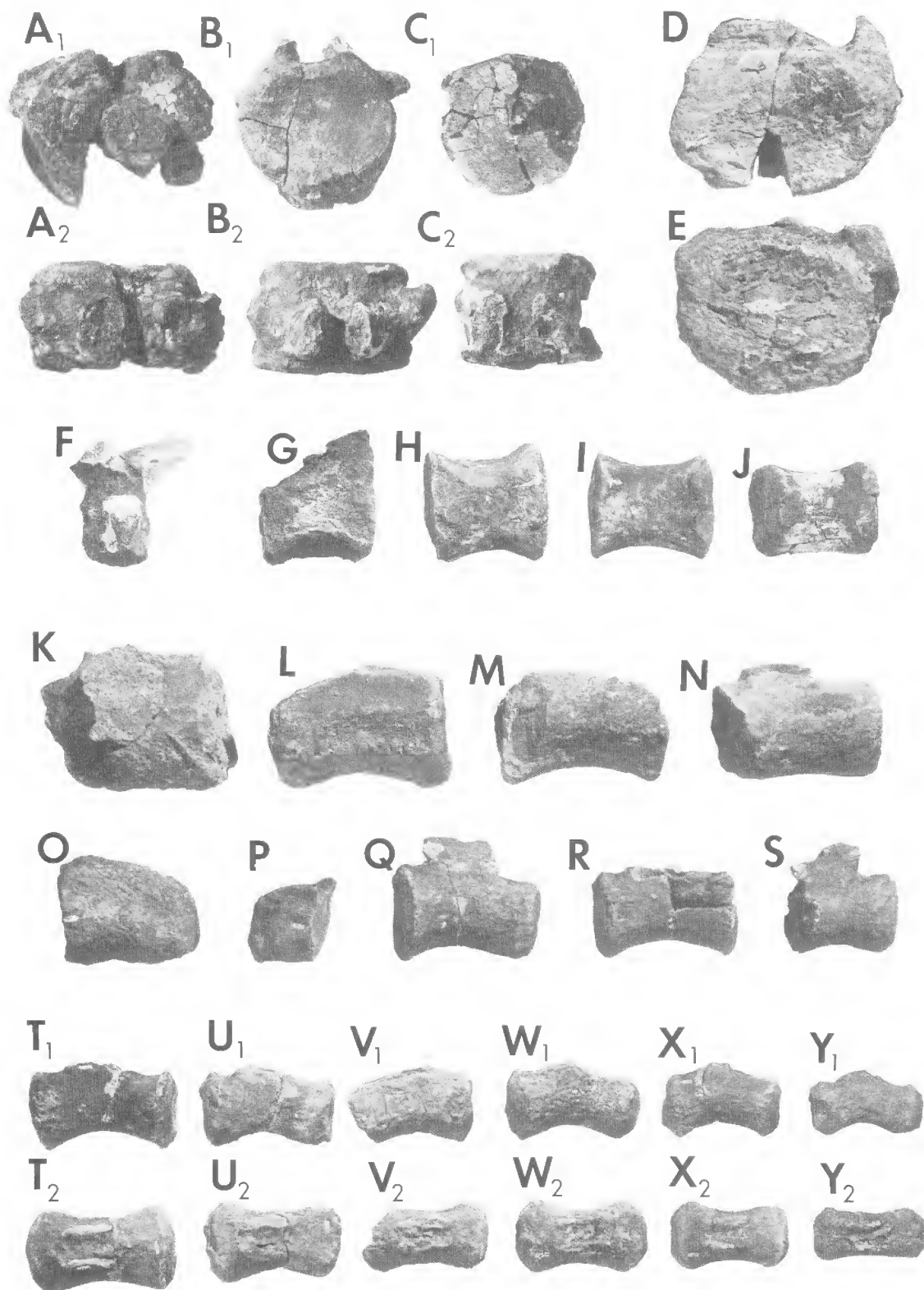


MEMOIRS OF THE QUEENSLAND MUSEUM

PLATE I

Caudal vertebrae. A<sub>1</sub> through C<sub>1</sub>, F6737, anterior caudals, anterior views; A<sub>2</sub> through C<sub>2</sub>, same vertebrae in dorsal view; D and E, F7292, middle caudals, anterior views; F, F6737, fragment of a neural arch with one prezygapophysis; G through J, F6737, distal caudals, ventral views; K through S, F7292, middle to distal caudals, lateral views; T<sub>1</sub> through Y<sub>1</sub>, F7292, distal caudals, lateral views; T<sub>2</sub> through Y<sub>2</sub>, same vertebrae as preceding in dorsal views. Approximately one-sixth natural size.



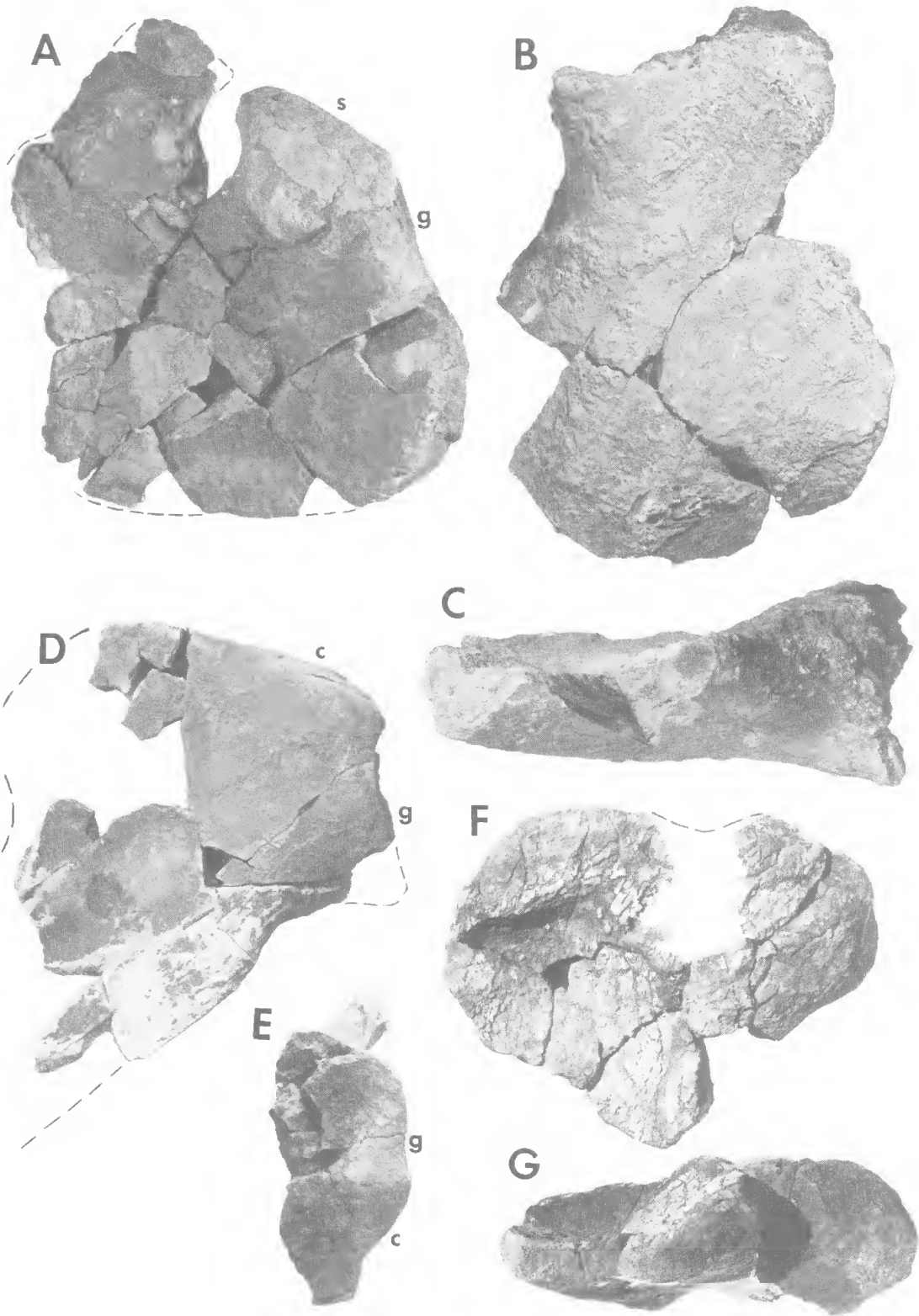


MEMOIRS OF THE QUEENSLAND MUSEUM

PLATE II

Girdle elements. A, F7880, left coracoid, medial view, g : glenoid, and s : scapular surface; B and C, F7292, ?coracoid, medial and edge views; D and E, F6737, left scapular fragment, medial view and view of glenoid, c : coracoidal, and g : glenoid surface; F and G, F7291, uncertain fragment, possible coracoid or fragment of ilium.

Approximately one-sixth natural size.

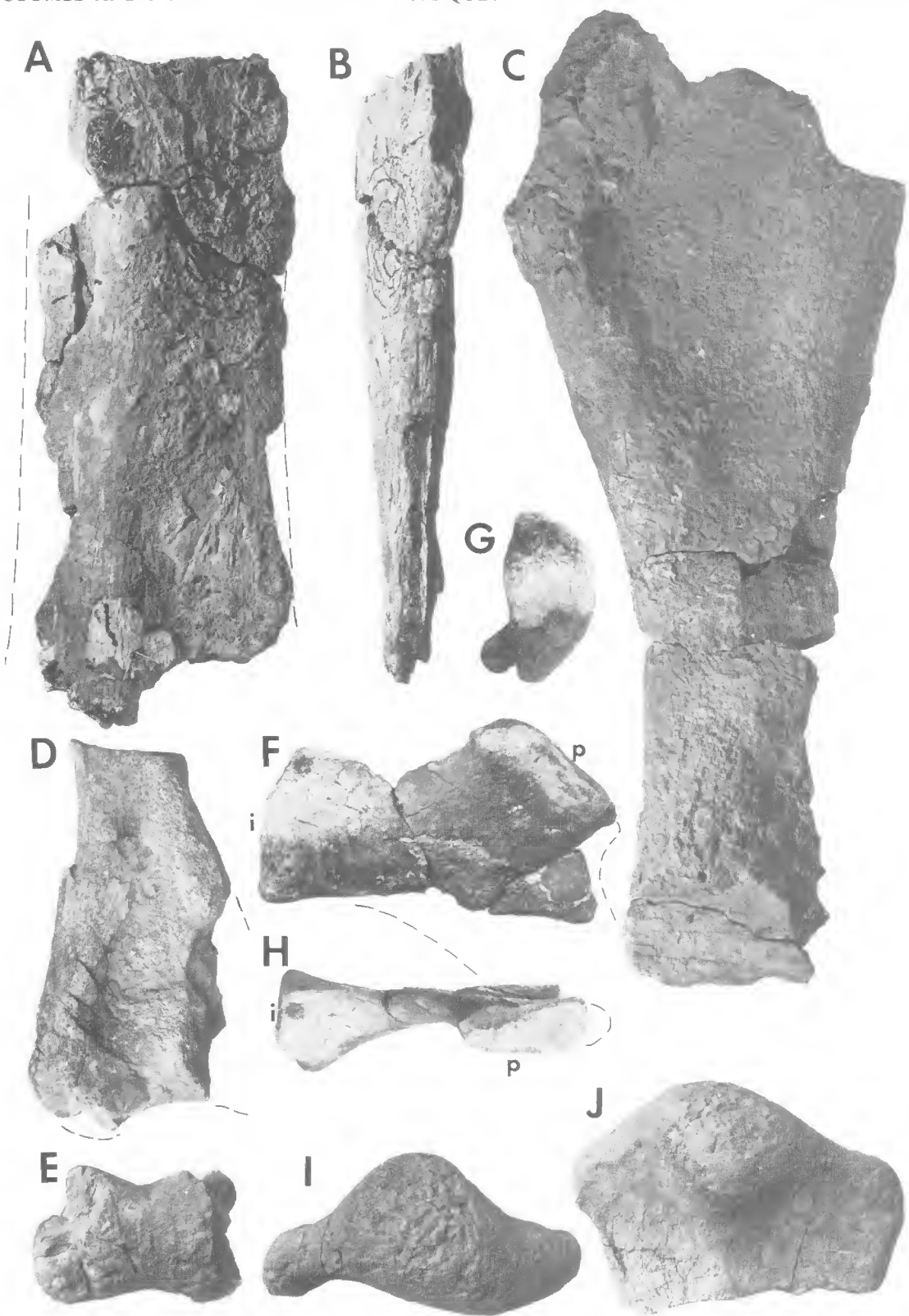


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PLATE III

Girdle and limb elements. A and B, F7292, scapular blade, lateral and edge views; C, F7292, left humerus, flexor surface; D and E, F3390, distal end of left? humerus, views of extensor surface and articular end; F, G, and H, F6737, fragmentary left ischium, lateral and anterior views, and view of iliac articular surface; I and J, F3390, proximal end of right humerus, views of proximal end and extensor surface, i : ilial and p : pubic articular surfaces. Approximately one-sixth natural size.

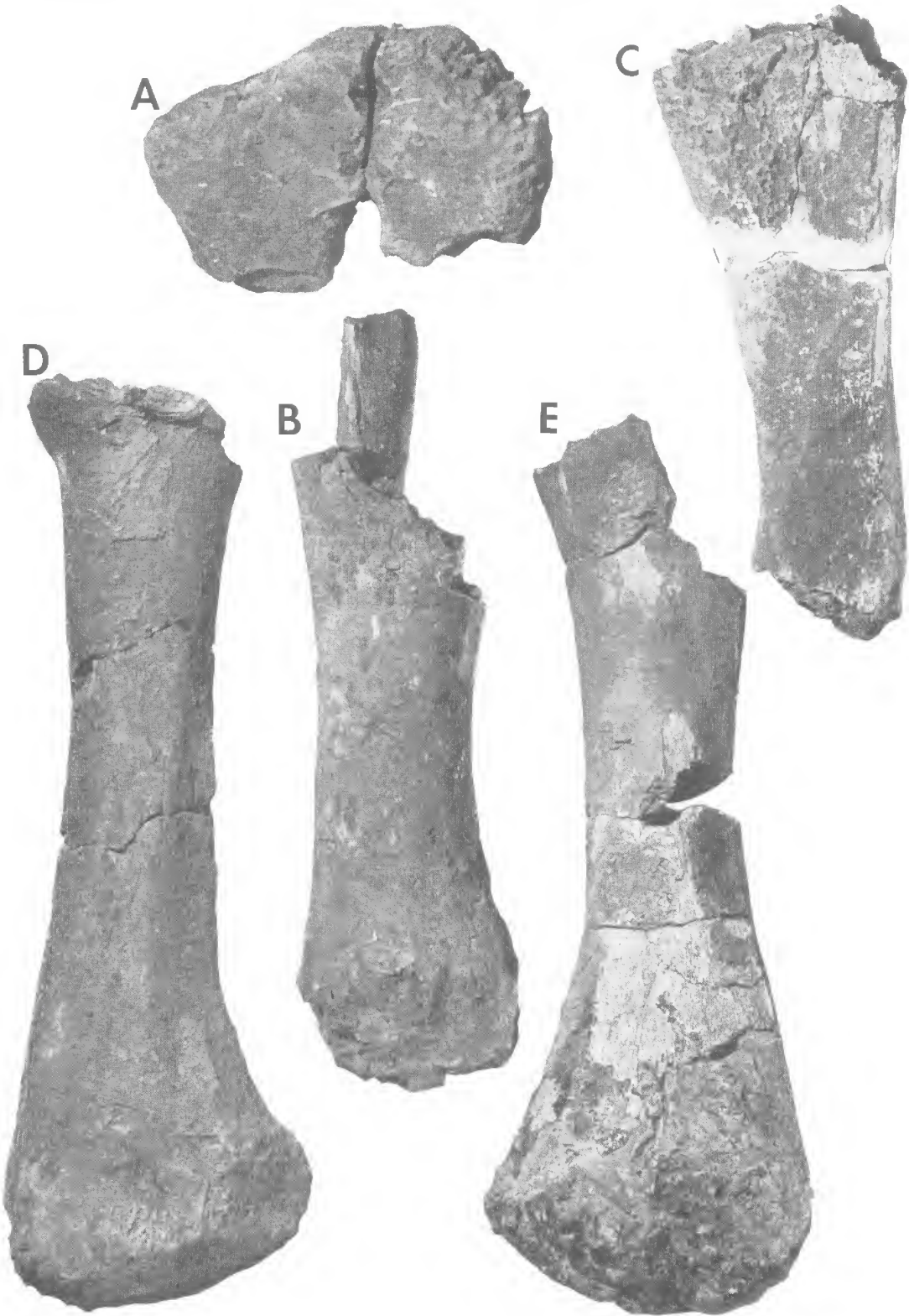




MEMOIRS OF THE QUEENSLAND MUSEUM

PLATE IV

Forelimb elements, all from specimen F7292. A, proximal end of an ulna, anterior view; B, distal end of an ulna, anterior view; C, shaft of an ulna, anterior view; D and E, two radii, ?lateral views. Approximately one-sixth natural size.

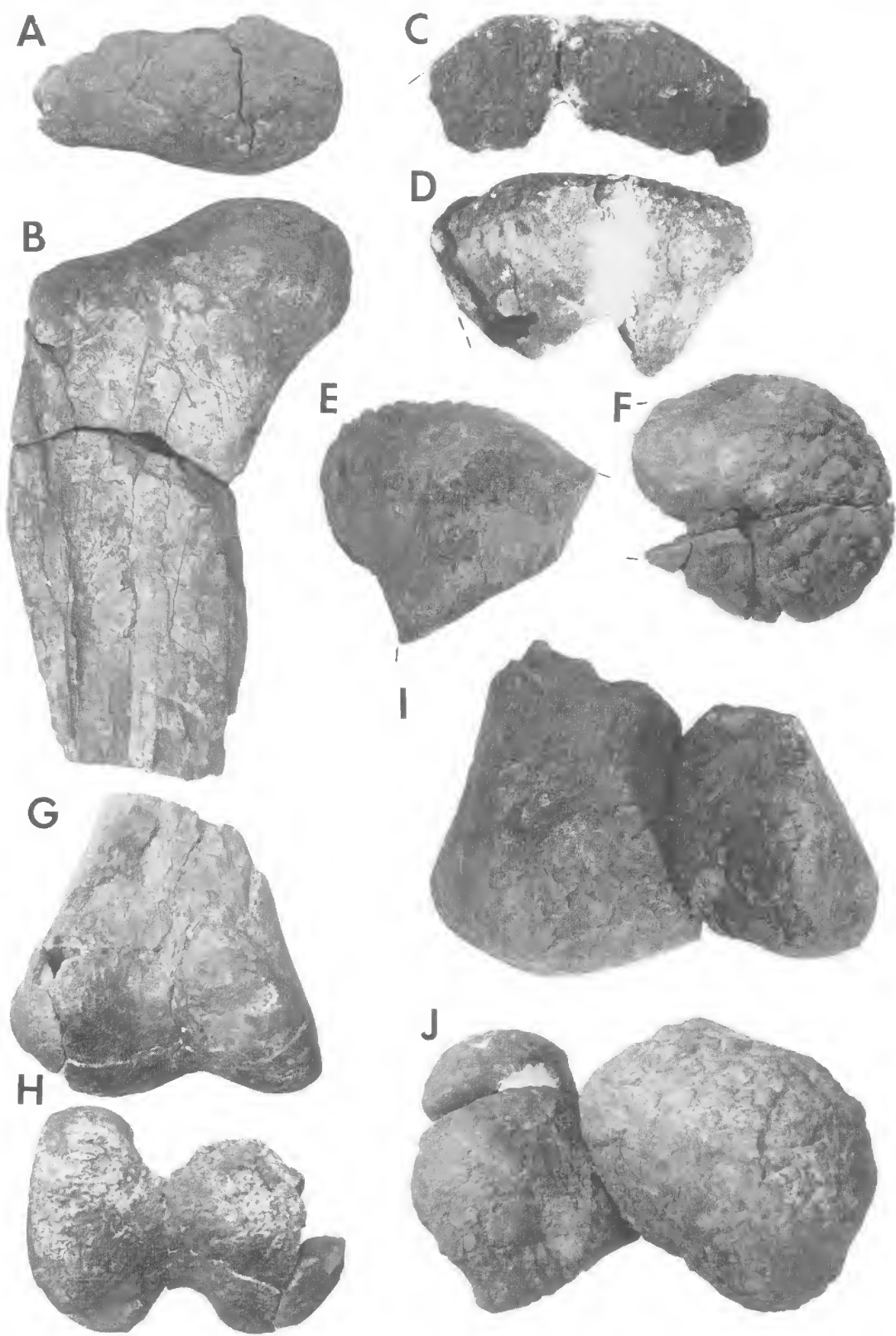


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PLATE V

Primarily hindlimb elements. A and B, F3390, proximal end of a femur, proximal and anterior views; C and D, F7291, uncertain fragment, possibly the proximal end of an ulna; E and F, F7880, head of a femur; G and H, F3390, distal end of a femur, posterior and distal views; I and J, F7291, broken distal end of a femur, anterior and distal views. Approximately one-sixth natural size.





MEMOIRS OF THE QUEENSLAND MUSEUM

PLATE VI

Meso- and metapodials. A, B, and C, F7292, metacarpal III, anterior, lateral, and proximal views; D and E, F7291, metacarpal I, anterior and proximal views; F and G, F7292, proximal half of metacarpal II, anterior and proximal views; H, F7292, distal half of a metacarpal, probably the same metacarpal II as the preceding, anterior view; I, F7292, metacarpal III, anterior view; J and K, F7292, proximal end of metacarpal II, proximal and ?lateral views; L through Q, F3390, metacarpals I, II, and III, proximal and ?anterior views; R and S, F7292, uncertain element, possibly a carpal, two views. Approximately one-sixth natural size.

